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ABSTRACT

Learned helplessness is a variable which has commonly been considered in research on sex-related differences in mathematics achievement. In this study, learned helplessness has been defined in terms of a debilitating or facilitating response resulting from failure on mathematical word problems. The construct has been called Performance Following Failure (PFF) to distinguish it from attributional definitions of learned helplessness. Algebra students (N=124) were given an ability measure, a mathematics achievement measure, and a PFF measure. Results showed that: (1) females (N=61) scored significantly lower than males (N=63) on the PFF measure, that is, they were more learned helpless; and (2) PFF was related to mathematics achievement for females but not for males. These findings indicated that a sex-related difference in PFF may be stronger than would have been expected from the related literature. It is suggested that PFF is a variable which needs to be considered when discussing sex-related differences in variables related to mathematics achievement. (Author/JN)

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Sex-Related Differences in Students' Reactions to Failure on Algebra Word Problems

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Paper presented at the annual meeting of the American Educational Research Association, Chicago, April 1985.

This paper is based on the author's doctoral dissertation, completed at the University of Wisconsin-Madison in 1984 under the direction of Professor Elizabeth Fennema.

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Abstract

Learned helplessness is a variable which has commonly been considered in research on sex-related differences in mathematics achievement. In this study, learned helplessness has been defined in terms of a debilitating or facilitating response resulting from failure on mathematical word problems. The construct has been called Performance Following Failure (PFF) to distinguish it from attributional definitions of learned helplessness.

124 algebra students were given an ability measure, a mathematics achievement measure, and a PFF measure. Results showed that: (a) females scored significantly lower than males on the PFF measure (i.e. they were more learned helpless); and (b) PFF was related to mathematics achievement for females but not for for males. These findings indicated that a sex-related difference in PFF may be stronger than would have been expected from the related literature. Certainly, PFF is a variable which needs to be considered when discussing sex-related differences in variables related to mathematics achievement.

Introduction

There is much anecdotal evidence to indicate that word problems have often caused considerable anxiety among students taking mathematics courses in elementary and secondary schools (Tobias, 1978). A few students seem to have such a fear of word problems that they give up on them without even trying. Many more students will give word problems a try but once they get stuck will cease to make a serious effort on any additional problems. Students who do give up in the face of failure have often been labeled learned helpless as they have "learned" that they are not able to complete tasks that other students can often do (Dweck & Goetz, 1978). In mathematics, many students feel that they are helpless, especially when it comes to doing word problems (Tobias, 1978). The implication for these students is that there is little sense in their putting forth effort as they are not going to be able to do the problem anyway. As proficiency at solving word problems is a topic of increasing concern among mathematics educators (An Agenda, 1980), it is important to do all we can to improve student motivation for doing word problems. In short, learned helplessness, particularly with respect to mathematics word problems, is an area where new research is essential.

In contrast to learned helpless students, there exists a second classification of students who see failure as a necessary, positive part of the learning process. These students, often referred to as mastery oriented, feel they can succeed and thus try harder rather than give up when difficult tasks arise (Dweck & Goetz, 1978). It should be pointed out, however, that most students are not clearly learned helpless or mastery oriented but are somewhere between the two extremes. I shall refer to the amount of mastery

orientation (and thus lack of learned helplessness) a student exhibits as his or her position on the mastery orientation/learned helplessness (MO/LH) continuum.

A topic of recent concern with respect to MO/LH is the existence of sex-related differences on this construct. Three recent reviews have indicated that females tend to be more learned helpless (and thus less mastery oriented) than males. Dweck and Licht (1980) made the claim that "A good deal of research has shown girls to be more helpless than boys in achievement situations" (p. 203). Kloosterman (1983) and Eccles (in press) reviewed sex-related differences in learned helplessness in mathematics. While agreeing that there was some evidence that females are more helpless than males, both reviews concluded that there was insufficient evidence to say that sex-related differences in learned helplessness were as strong as had been implied by Dweck and Licht.

Another point of some controversy is the relationship between MO/LH and achievement, particularly within the subject area of mathematics. While such a relationship has been theoretically established (Covington & Beery, 1976; Kloosterman, 1984) additional empirical evidence supporting the relationship is needed. Specifically, the questions of whether mastery oriented students are higher achievers than learned helpless students and whether MO/LH accounts for a significant amount of the variation in a regression equation predicting achievement need to be answered. In addition to overall sex-related differences in MO/LH, the current study considered these questions.

One final point concerning an operational definition of learned helplessness needs to be clarified at this time. Up to this point, I have spoken about learned helplessness as a debilitating reaction to failure. In

other words, a learned helpless individual is one who gives up when a task appears difficult. While this definition is common, a second definition in terms of attributions for success and failure is also common (Dweck & Goetz, 1978; Eccles, in press). As the current study deals only with reaction to failure to define MO/LH, I have used the phrase "performance following failure" (PFF) to mean a student's MO/LH as measured by his or her reaction to failure. The instrument used to measure students' reactions to failure in this study was called the Performance Following Failure Scale and yielded integer scores ranging from -5 to +5. A positive score indicated that an individual's performance improved after failure (mastery orientation). A negative score indicated that an individual's performance deteriorated after failure (learned helplessness). In short, this study was designed to: (a) investigate sex-related differences in performance following failure; (b) investigate whether students with positive PFF scores achieved higher in mathematics than students with negative PFF scores; and (c) see whether PFF accounted for a significant portion of the variance in a regression equation predicting mathematics achievement.

Method

Procedure

In this study, the relationship between students' scores for ability, PFF, and mathematics achievement was of primary concern. To collect this information, students were tested over a period of two weeks. The first two testing sessions were done with entire classes. On day one, students completed the ability measure and the first part of the PFF measure. The achievement measure was administered on the following day. The second part of

the PFF measure was given at a later time to groups of two to six students during study halls. The small groups were necessary for two reasons. First of all, it was necessary for the testor to grade each problem as soon as that problem was completed so that students knew they had answered the failure problems incorrectly. Secondly, the failure problems created frustration in students but by keeping the group size small, communication of that frustration to other students was minimized.

Sample

The sample consisted of 63 males and 61 females enrolled in an algebra course at one of three rural/suburban schools in south-central Wisconsin. 16 of the females and 17 of the males were ninth-grade students enrolled in basic algebra courses while the remainder of the students were in ninth or tenth grade and enrolled in algebra I. Almost all students in the sample were white.

Instruments

Ability. Students' ability was measured by level 1, form Am of the Quick Word Test (QWT) (Borgatta & Corsini, 1964). The instrument consists of 100 multiple choice items which require the subject to choose from a set of four words the one which means the same as a given word. The QWT was selected because of the brief time required for administration (about 15 minutes) and because Borgatta and Corsini (1964) reported that the test correlated highly ($r=.83$) with the total score from the Weschler Adult Intelligence Scale. The split-half reliability of the Quick Word Test was reported as .93 for ninth-grade students (Borgatta & Corsini, 1964).

Performance Following Failure. I developed the performance following failure (PFF) measure for this study to measure students' reactions to failure on algebra word problems. The instrument was modeled after a learned helplessness measure used by Dweck and Reppucci (1973) in which failure was induced by asking students to complete unsolvable puzzles. The major difference between the current measure and the one used by Dweck and Reppucci was that the task on the current measure involved mathematical word problems of the type often found in high school mathematics classes. The PFF instrument, shown in Appendix A, contains two categories of word problems. The ten problems which I have called "success" problems were each correctly solved about 50% of the time by algebra students during pilot testing. It was these problems which I used to assess student performance on word problems. Six additional problems, which I have called "failure" problems, were exceptionally difficult although they appeared reasonable to algebra students. After the pilot testing, the failure problems were divided into two groups of three. Those in the first group were the "easiest" of the failure problems, having been answered correctly about 13% of the time by students during the piloting. Those in the second group were the hardest, having been answered correctly only 2% of the time.

Part I of the Performance Following Failure instrument consisted of six of the ten success problems, randomly selected for each student and printed out as a six-item test. Note that because of the random selection of problems for each student, part I of the instrument consisted of somewhat different problems for different students. The purpose of the part I problems was to get a baseline word problem performance score for each student.

Part II of the PFF instrument used the failure problems and the remaining four success problems to induce failure in the students and then measure their achievement after that failure. A part II booklet consisted of: (a) the three easiest failure problems (randomly ordered); followed by (b) the three hardest failure problems (randomly ordered); followed by (c) the four success problems not used for part I (randomly ordered). The ordering (3 "easier" failure problems, 3 "harder" failure problems, and 4 success problems) was designed to make sure that the students were experiencing failure by the time they began work on the success problems. Students were required to work through the problems in part II in the order they appeared in the booklet to make sure that they did not do the success problems first. Also, as each problem was checked when it was completed, there was no chance a student would think that a failure problem had been done correctly when it had not. KR-20 reliabilities were calculated for the success problems and were found to be .59 for the six success problems before failure and .52 for the four success problems after failure.

A Peformance Following Failure score was calculated for each student based on the number of success problems correct after failure in relation to the number of problems correct before failure. Using the guidelines that: (a) students whose achievement improved after the failure problems should have positive PFF scores and those whose achievement deteriorated after the failure items should have negative PFF scores; and (b) the magnitude of the scores should reflect the level of increase or decrease in performance after the failure problems; a transformation mapping student scores before and after failure into a PFF score was set up. That transformation is shown in Table 1.

Mathematics Achievement. Overall achievement in mathematics was measured by Level 1, Form X of the STEP III Mathematics Basic Concepts Subtest (STEP Basic Assessment, 1979). This 50 item multiple choice test was designed to measure mastery of mathematical concepts as opposed to arithmetic computation. Each item had one correct answer which was worth one point when the test was scored. The split-half reliability of the instrument was reported as .91 for ninth-grade students (STEP Basic Assessment, 1979).

Results

Sex-Related Differences on PFF.

Table 2 shows means, standard deviations, and t's for sex-related differences on all study variables. As can be seen from the table, the mean Performance Following Failure (PFF) score for males was positive (0.44) indicating that males had a tendency to achieve higher after the failure problems than they had before the failure problems. In contrast, the mean score for females was negative (-0.25) indicating that they had a tendency to achieve lower after the failure problems than they had before the failure problems. A t-test showed that the difference between the males' and the females' scores was statistically significant ($t=-2.23$, $p<.05$) indicating that females scored significantly lower on PFF (i.e. they were more learned helpless) than males.

Mathematics Achievement of High and Low PFF Groups.

One way to assess the relationship between performance following failure and mathematics achievement is to divide students into subgroups based on whether their PFF scores were positive (mastery orientation) or negative

(learned helplessness). Students who had a score of zero were not used for this portion of the analyses as such a score indicated that failure had little effect on their performance.

To assess the relationship between PFF and achievement, mathematics achievement scores of students with positive PFF scores were compared to mathematics achievement scores of students with negative PFF scores. As there was a sex-related difference on PFF (Table 2), analyses were done separately for females and males. Table 3 shows achievement scores and t-test results for females with positive and negative PFF scores and for males with positive and negative PFF scores. As can be seen from the table, females with positive PFF scores achieved significantly higher than females with negative PFF scores ($t=2.20$, $p<.05$). Males with positive PFF scores, however, achieved lower than males with negative PFF scores although the difference was not statistically significant ($t=-0.11$).

PFF and Ability as Predictors of Mathematics Achievement.

A second method of judging the impact of PFF on achievement was to use PFF and ability scores as independent variables in a regression equation where mathematics achievement was the dependent variable. This procedure was carried out using the NEW REGRESSION subprogram of SPSS (Nie, Hull, Jenkins, Steinbrenner, & Brent, 1975). This subprogram adds the independent variable which accounts for the greatest amount of variance in the dependent variable into the regression equation first. Other variables are added only if they add significantly to the unaccounted for variance in the dependent variable.

Table 4 shows that for females, ability scores accounted for 30% of the variance in achievement scores (R^2) while PFF accounted for another 6% of the

variance. The increase in R^2 was significant at the p=.05 level. For males, ability accounted for 36% of the variance in achievement scores (R^2) but PFF did not account for a significant additional portion of that variance. In other words, for females, PFF was a significant predictor of achievement beyond that accounted for by ability. For males, however, PFF did not account for a significant amount of students' achievement beyond that accounted for by ability.

Discussion

Sex-Related Differences

The finding that females had significantly lower PFF scores (i.e. they were more learned helpless) than males in this study was not surprising in terms of the literature (Dweck & Licht, 1980). However, the additional findings that: (a) dividing females into groups with positive and negative PFF scores resulted in groups that were significantly different in achievement but dividing males into such groups did not differentiate the groups by achievement; and (b) PFF accounted for mathematics achievement beyond that accounted for by ability for females only; indicate that PFF is an important influence on mathematics achievement for females but that does not appear to be the case for males. This is a much stronger finding than had been reported in the literature on sex-related differences in learned helplessness (Kloosterman, 1983; Eccles, in press).

While it is difficult to say precisely why PFF was a factor in achievement for females but not for males, two distinct features of the current study may account for part of the strength of the findings in relation to findings of other studies. The first involves the fact that while other

studies of learned helplessness were done with puzzles or computational mathematics (Diener & Dweck, 1978; Dweck, 1975; Dweck & Reppucci, 1973), the current study was done with mathematical word problems similar to those found in high school mathematics. The second distinct feature of the current study was that other studies (Diener & Dweck, 1978; Dweck, 1975; Dweck & Reppucci, 1973) were done with children in grades 4 through 6 while the current study was done with students in grades 9 and 10. It is difficult to say how these features of the current study resulted in a relationship between PFF and achievement for females but not for males. We know that sex-related differences in mathematics achievement are greatest in favor of males near the end of high school when problems involving mathematical knowledge and application rather than computational skills are considered (Fennema & Carpenter, 1981). In other words, as students get older and as problems require more mathematical abstraction, sex-related differences in mathematical achievement increase. As PFF is related to achievement, sex-related differences in PFF may be in some way related to sex-related differences in mathematics achievement and thus such differences would be expected to increase as students got older and as the mathematics considered became increasingly abstract.

Measurement of Performance Following Failure

Development of the performance following failure instrument used for this study requires discussion to counter the argument that the findings reported were an artifact of the instrument rather than the construct it was supposed to measure. I will begin by claiming that the PFF instrument does measure mastery orientation/learned helplessness (MO/LH) when defined as a

debilitating or facilitating behavioral responses to failure. I maintain that the measure does induce failure as evidenced by the fact that the three hardest failure problems were only answered correctly about 2% of the time. In addition, a PFF score is based on the number of problems correct after failure in relation to the number correct before failure. As the problems after failure average the same difficulty as those before failure (because a "before" problem for one student may have been an "after" problem for another student and visa versa), it is reasonable to argue that changes in performance after failure were the direct result of experiencing that failure. The reliability of the instrument was not high (.59 for the problems before failure and .52 for the problems after failure) but was not unreasonable given that the problems were randomly ordered and it was the total score after failure in relation to the total score before failure that was of interest. In short, the PFF instrument appears to be a reasonable way to measure MO/LH when defined in terms of reaction to failure and thus it is unlikely that results of this study are an artifact of that instrument.

Conclusions

The findings of a sex-related difference in performance following failure and in the relationship between PFF and mathematics achievement clearly indicate that PFF is a variable that should be considered when studying sex-related differences in the learning of mathematics. The instrument used in the current study appears to be a good measure of PFF as the construct has been defined. While it would be helpful for teachers to be aware that there is a tendency for females to react to failure in a more negative way than males, the use of the PFF instrument by classroom teachers is probably not

appropriate as once students had learned that the purpose of the failure problems was to induce failure, this method of inducing failure would no longer be effective. For researchers however, performance following failure is a good operational definition of mastery orientation/learned helplessness as defined by a debilitating response to failure and thus work with the construct needs to be continued.

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Table 1

Mapping used to Create Performance Following Failure Scores from Pre-Failure and Post-Failure Scores

Ordered Pair [a]	Performance Following Failure Score
(0,4)	+5
(1,3), (1,4), (0,3)	+4
(2,4), (1,2), (0,2)	+3
(3,4), (2,3), (0,1)	+2
(5,4), (4,4), (3,3), (2,2), (1,1)	+1
(6,4), (5,3), (4,3), (3,2), (0,0)	0
(6,3), (5,2), (4,2), (2,1), (1,0)	-1
(6,2), (3,1), (2,0)	-2
(5,1), (4,1), (3,0)	-3
(6,1), (5,0), (4,0)	-4
(6,0)	-5

[a] The first number in the ordered pair was the number of problems solved correctly before the six failure items while the second was the number of problems solved correctly after the failure items. The mapping was created by looking at the ratio of the percentage of problems correct after failure to the percentage of problems correct before failure. Ratios involving a zero for either score were then added to the mapping.

Table 2

Means, Standard Deviations, and t's for Sex-Related Differences on all Study Variables

Variable	Possible Range	Females[a] $\bar{x}$	Females[a] (s.d)	Males[b] $\bar{x}$	Males[b] (s.d.)	t[c]
PFF Score	-5 to 5	-0.25	(1.83)	0.44	(1.60)	-2.23*
STEP Basic Concepts (Achievement)	0 to 50	35.62	(6.22)	37.16	(6.45)	-1.35
Quick Word Test (Ability)	0 to 100	53.84	(11.95)	54.52	(10.08)	-0.35
PFF Before-Failure Achievement	0 to 6	2.92	(1.74)	2.84	(1.73)	0.25
PFF After-Failure Achievement	0 to 4	1.80	(1.36)	2.21	(1.18)	-1.76
Achievement on PFF Failure Problems	0 to 6	0.39	(0.67)	0.40	(0.77)	-0.03

[a] n=61

[b] n=63

[c] * $p<.05$

Table 3

Means, Standard Deviations, and t's for Differences in Mathematics Achievement Between Students with Positive PFF Scores and Students with Negative PFF Scores

	Positive PFF Scores		Negative PFF Scores		t[a]
Group	$\bar{x}$	(s.d.)	$\bar{x}$	(s.d.)	
Females[b]	37.65	(4.40)	34.11	(6.57)	2.20*
Males[c]	35.97	(6.82)	36.19	(5.42)	-0.11

[a] * $p<.05$

[b] for positive PFF, n=23; for negative PFF, n=27

[c] for postive PFF, n=29; for negative PFF, n=16

Table 4

Linear Stepwise Regression of Ability (Quick Word Test) and PFF Scores on Mathematics Achievement Scores[a]

	Females[b]			Males[c]		
Step	Variable	R^2	F-ratio	Variable	R^2	F-ratio
(1)	Ability	.30	25.38*	Ability	.36	33.92*
(2)	PFF	.36	5.25*			

[a]Only variables which add significantly to the variance at $p<.05$ were added to the equation.

[b]n=61

[c]n=63

* $p<.05$

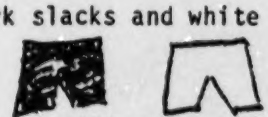
APPENDIX A: PERFORMANCE FOLLOWING FAILURE INSTRUMENT

The items below, when given to students, were printed one item per page and stapled together to form test booklets. Six of the success items were randomly selected and randomly ordered for each student to form part 1 of the test. Part 2 of the test was a booklet of problems assembled as follows. The first three failure problems were randomly ordered for each student and included as the first three pages of the booklet. The second three failure items were randomly ordered and included as pages 4 through 6 of the booklet. Finally, the four success items not used in part 1 (the items were different for each student) were randomly ordered and presented as the last four pages of the booklet.

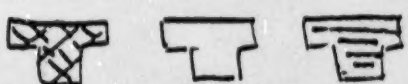
Success Items

1. A hockey team won six of the 20 games it played. What percent of the games did it win?

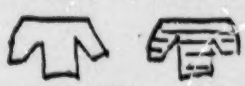
2. Dale had dark slacks and white slacks.



Dale also had 3 different shirts. They were plaid, plain, and striped.



Finally, Dale had a white jacket and a striped jacket.



How many different outfits (slacks, shirt, and jacket) could Dale wear?

3. Juan's mother has three five-dollar rolls of dimes and two ten-dollar rolls of quarters to use for Juan's school lunches. If Juan takes exactly forty-five cents to school every day for his lunch, which of the following statements is true?

   a. He uses all of the quarters before all of the dimes.

   b. He uses all of the dimes before all of the quarters.

   c. He spends all of both coins at the same time.

   d. I don't know.

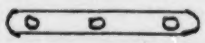
4. The air temperature on the ground is 31 degrees. On top of a nearby mountain, the temperature is -18 degrees. How many degrees difference is there between the two temperatures?

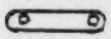
5. Ms. Hernandez needs three ribbons. One must be 6 feet 5 inches long, the second must be 8 feet 11 inches long, and the third must be 4 feet 9 inches long. How many INCHES of ribbon does she need?

6. If Ellen drives a car at an average speed of 52 miles an hour, how many hours will it take her to travel 325 miles?

7. A parking lot charges 35 cents ffor the first hour and 25 cents for each additional hour or fraction of an hour. For a car paked from 10:45 in the morning until 3:05 in the afternoon, how much money should be charged?

8. Mike's building set has

   60 long pieces 

   60 short pieces 

   and 60 nuts with bolts

   How many of these can he make?

9. A woman has 1310 baseballs to pack in boxes which hold 24 balls each. How many baseballs will be left over after the woman has filled as many boxes as she can?

10. Some people suggest the following formula be used to determine the average weight for boys between the ages of 1 and 7:

$$W=17+5A$$

where W is the average weight in pounds and A is the boy's age in years. According to this formula, for each year older a boy gets, how much more should he weigh?

Failure Items (first three)

1. How many cubic feet of concrete would be needed to pave an area 32 feet long and 21 feet wide with a layer four inches thick?

2. A bill for electricity contains the following information:

Present Reading	Previous Reading	Consumed	Bill
1548 kw-hr	942 kw-hr	606 kw-hr	9.09

How much is the customer paying per kilowatt hour for electricity?

3. If each of nine teams in a bowling league plays every other team ONCE, how many games will be played in all?

Failure Items (second three)

4. A cereal company is running a contest in which they will send the winner some money every day during the month of August. The winner will receive 1234 dollars on August first, twice that amount on August second, three times that amount on August third, and so on. If you win the contest, how much money will you will altogether?

5. Triskaidekaphobia is fear of the number 13. Friday falls on the thirteenth day of the month 48 times every 28 years. What is the chance that any given Friday falls on the thirteenth?

6. The name of the magazine published by the San Diego Zoo is ZOONOOZ. How many different names could be made by changing the order of these seven letters? (For example, the letters could be rearranged to make names such as OZONOOZ, OOOZNOZ, NOZOOZ, ZZOOON, OZONOZO, etc.)